Pollen Types Collected by Honey Bees at Three Localities on the Island of Hawaii Part I: Floral Source Identification

LORNA H. ARITA, WILLIAM S. SAKAI, and JADELYN J. MONIZ[1]

ABSTRACT

Pollen pellets removed from the hindlegs of honey bees returning to their hive, were collected on a monthly basis at 200 ft elevation at Hakalau and Panaewa, and at 4000 ft elevation at Volcano, all on the island of Hawaii. Pollen pellet samples were visually separated by color and identified as to floral source at the family level.

These samples contained 97 pollen types from 29 plant families. Sixty-three pollen types were found exclusively at a single location; 23 types from 10 families at Hakalau, 12 types from 9 families at Panaewa, and 28 types from 15 families at Volcano. Thirty-four pollen types were found at more than one location; 5 types from 4 families at Hakalau and Panaewa, 6 types from 6 families at Panaewa and Volcano, and 14 types from 10 families at Hakalau and Volcano. Nine pollen types from 7 families were common to all three locations.

The worker caste of the honey bee, *Apis mellifera* L. (Hymenoptera: Apidae), performs most of the maintenance activities essential for the survival of the colony, including the collection of pollen which is used as food for larval development (Haydak 1934). Pollen grains, which collect between the dense hairs on the body of the worker, are removed and compressed into pellet form. The pellet is placed into the pollen basket (corbiculum), located on the outer face of each hindleg (Thorp 1979), and once the baskets are fully loaded, the worker returns to the hive to store the pollen for later use.

On each pollen gathering trip, honey bees usually collect pollen from only one plant source. The selective collection of pollen produces homogenous pollen pellets which are thought to be of importance to larval development because of differences in the nutritional value of the pollens from different plant sources (Auclair and Jamieson 1948).

Hawaii's flora is unique because it contains many exotic as well as endemic, flowering plants. However, many plant species are restricted to specific locations. A study by Moniz et al. (in press) indicated that honey bees collected pollen from several floral sources, but identification of pollen types to the family level was not made. The present study was conducted to identify the floral sources of pollens collected by honey bees at Hakalau, Panaewa, and Volcano, Hawaii.

[1]University of Hawaii at Hilo, College of Agriculture, Hilo, Hawaii 96720-4091.

MATERIALS AND METHODS

Pollen Collection. At each of the three localities (Hakalau, Panaewa, and Volcano), a pollen trap (Walter T. Kelly Co.) was placed at the entrance of a two story hive. One day prior to the placement of the pollen trap, the regular entrance to the hive, located between the lower hive body and the bottom board, was covered with a #3-mesh hardware cloth. At that time, a new entrance was created by placing two separation boards between the two hive bodies. After the bees were allowed a 24 hour acclimation period, the pollen trap was placed at the new entrance. The trap consisted of an entry port lined with #5-mesh hardware cloth, which prevented returning workers from entering the hive with the pollen pellets. Only after most of the pellet was removed by the hardware cloth could the bee continue into the hive. The dislodged pollen pellets were collected in a tray located under the entry port.

From November 1986 to November 1987, monthly pollen samples were collected from Volcano (elevation 4000 ft) and Hakalau (elevation 200 ft). Monthly samples were collected from Panaewa (elevation 200 ft) from November 1986 to March 1987 when they were terminated due to farm expansion. The pollen trap was placed on the hive at each locality for 10 consecutive days each month since continuous use of the trap was not possible because of the need for pollen by the bees.

Separation and Plant Identification of Pollen Pellets. For each locality, the monthly pollen samples were separated by color of the pellet. Once separated by color groups, pellets were further separated into pollen types based on the structure of the pollen grains.

Several guides to pollen identification were used to identify the samples (Bennett 1985; Erdtman 1969; Faegri and Iverson 1975; Roth and Durham 1964; Selling 1946, 1947, 1948). Confirmation was made by collecting the plants flowering in the vicinity of each hive on a monthly basis and photographing (40×) the pollen grains from the flowers. Photographs of the pollen grains from identified plants were compared with the trap samples. Scanning electron microscopy was also used to identify some plant sources, especially when pollen grains were similar.

RESULTS AND DISCUSSION

Data on the locality, average size and color of pollen pellets, and plant sources are provided in Table 1. For detailed descriptions of size, shape, and structures of the pollen grains for each plant family refer to Selling (1946, 1947, 1948) and Bennett (1985).

There were 51 pollen types collected at Hakalau, 32 types at Panaewa, and 57 at Volcano. These numbers are similar to the total number of pollen types (46) collected by bees from a single hive in southern Ontario (Adams et al. 1978). The data of Adams et al. indicated that there was seasonal variation in the pollen types collected, and, therefore, by monitoring the pollen for a one year period all of the types collected could be determined.

A portion of the pollen types collected during our study were found at more than one location, so the total number of different pollen types found was 97, representing 29 families. Of these, 23 types from 10 families were found exclusively at Hakalau, 12 types from 9 families were found only at Panaewa, and 28 types from 15 families were collected only at Volcano. Thus, 63 pollens, or 64.9% of all pollen types collected, were unique to a specific locality.

Of the remaining 34 pollen types found at more than one location, there were 5 types from 4 families common to Hakalau and Panaewa, but not found in Volcano; 6 types from 6 families collected at Panaewa and Volcano, but not at Hakalau; and 14 types from 10 families found at Hakalau and Volcano, but not collected at Panaewa. There were 9 types from 7 families that were common to all these localities.

Plant families with large numbers of pollen types included the Compositae, Solanaceae, and Urticaceae. Several of these appeared to be exotic species that occurred at more than one location.

Because of the large number of pollen types and families represented in our collections, we speculate that, in addition to foraging for pollen based on seasonal variation and availability, several pollen types may be actually sought out by bees for their nutritive value. Pollen is the primary source of essential amino acids for honey bees (McCaughey and Standifer 1980). But the pollens from different plants do not hold the same nutritive value. Studies conducted by Campana and Moeller (1977), and Herbert et al. (1970), showed that the number of honey bees produced in a colony varied based on the source of pollen provided. Thus, a mixture of different pollens brought into the hive would be advantageous to the production of brood.

Adams et al. (1978) determined that honey bees in southern Ontario foraged on both native and introduced plants, which included anemophilus (wind pollinated) as well as entomophilus (insect pollinated) species. Similarly, in our study, pollens were collected from endemic and exotic flowering plants. Plant distance from the hive and availability of pollens appeared to be the determining factors in the types of pollens collected.

The identification to family level of the different pollen types collected by honey bees provides valuable information for beekeepers in determining the floral composition of their honeys. In addition, many pollens collected by honey bees are the cause of allergenic reactions in humans. The use of honey bees to collect pollen provides a means of acquiring homogeneous pollen samples which can be used in the production of allergenic extracts for patient testing and treatment. By monitoring the seasonal blooming pattern of the predominant floral sources, the need for preventive patient treatment prior to the onset of floral bloom can be predicted.

ACKNOWLEDGMENTS

We thank Edmundo Reyes, Kevin Klein, and Robyn Morris for data collection. We also wish to thank Sheldon Furutani and Michael Tanabe for plant identification. This study was supported by UH Research and Training Grant 21-R88-846-F-728-B-286.

REFERENCES CITED

Adams, R. J., G. C. Manville, and J. H. McAndrews. 1978. Comparison of pollen collected by a honey bee colony with a modern wind-dispersed pollen assemblage. Can. Field Nat. 92(4):359-368.

Auclair, J. L. and C. A. Jamieson. 1948. A qualitative analysis of amino acids in pollen collected by bees. Science 108:357-358.

Bennett, T. M. 1985. Palynology of selected horizons from the Ewa coastal plain, Oahu, Hawaii. M.S. Thesis. University of Hawaii.

Campana, B. J., and F. E. Moeller. 1977. Honeybees: preference for and nutritive value of pollen from five plant sources. J. Econ. Entomol. 70:39-41.

Erdtman, G. 1969. Handbook of palynology. Hafner Press. New York.

Faegri, K. and J. Iverson. 1975. Textbook of pollen analysis. Blackwell Science, Oxford.

Haydak, M. H. 1934. Changes in total nitrogen content during the image of the worker honey bee. J. Agric. Res. 49:21-28.

Herbert, E. W., W. E. Bickley, and H. Shimanuki. 1970. The broodrearing capability of caged honeybees fed dandelion and mixed pollen diets. J. Econ. Entomol. 63:215-218.

McCaughey, W. F., M. Gilliam, and L. N. Standifer. 1980. Amino acids and protein adequacy for honey bees of pollens from desert plants and other floral sources. Apidologie 11:75-86.

Moniz, T. T., L. H. Arita, and J. K. Fujii. 1989. Quantity and color types of pollen collected by honey bees in a hive in Panaewa, Hawaii. Proc. Hawaii. Entomol. Soc. 29.

Roth, A. and O. Durham. 1964. Pollen and mold survey in Hawaii. J. Allergy. 36(2):186-189.

Selling, O. H. 1946. Studies in Hawaiian pollen statistics. Part I. The spores of the pteridophytes. B. P. Bishop Mus. Sp. Publ. 37.

Selling, O. H. 1947. Studies in Hawaiian pollen statistics. Part II. The pollens of the Hawaiian phaerograms. B. P. Bishop. Mus. Sp. Publ. 38.

Selling, O. H. 1948. Studies in Hawaiian pollen statistics. Part III. On the late quartnary history of the Hawaiian vegetation. B. P. Bishop Mus. Sp. Publ. 38.

Thorp, R. W. 1979. Structural, behavioral, and physiological adaptations of bees (Apoidea) for collecting pollen. Ann. Missouri Bot. Gar. 66:788-812.

TABLE 1. Pollen types collected by honey bees in Hakalau (H), Panaewa (P), Volcano (V), Hawaii including pellet description and floral source identification to family level.

Floral Source (Family name)	Pollen Pellet Description (color, size — mm)	Locality		
Anacardiaceae	brown, 2.0 mm			V
Celastraceae	orange yellow, 2.5 mm	H	P	V
Compositae	light brown, 2.5 mm		P	
Compositae	light yellow beige, 2.5 mm			V
Compositae	light beige, 2.0 mm	H		V
Compositae	orange brown, 2.5 mm	H		
Compositae	dull yellow, 2.0 mm	H		
Compositae	beige, 1.5 mm		P	V
Compositae	dark orange, 3.0 mm	H		V
Compositae	dark orange, 3.0 mm			V
Compositae	gray, 3.0 mm	H		V
Compositae	bright orange, 3.0 mm	H		V
Compositae	light yellow, 3.0 mm			V
Compositae	yellow orange, 2.0 mm	H		
Compositae	brown yellow, 2.5 mm	H		
Compositae	brown orange, 3.5 mm	H		
Compositae	light orange brown, 3.0 mm	H		
Compositae	gold brown, 3.0 mm		P	
Cyperaceae	orange, yellow, 4.0 mm	H	P	V
Cyperaceae	light orange yellow, 2.5 mm	H		
Cyperaceae	purple, 2.0 mm	H		V
Epacridaceae	light yellow, 3.0 mm			V
Euphorbiaceae	light brown, 3.0 mm	H		V
Gesneriaceae	beige, 2.5 mm	H		
Iridaceae	orange, 2.5 mm		P	V
Labiatae	beige, 3.0 mm	H	P	
Lauraceae	brown yellow, 2.5 mm			V
Liliaceae	brown with yellow edges, 3.0 mm		P	V
Liliaceae	light brown, 2.0 mm	H		V
Liliaceae	dark orange brown, 3.0 mm			V
Liliaceae	gray brown, 2.0 mm	H		
Liliaceae	dark orange, 2.0 mm		P	
Liliaceae	orange brown, 2.5 mm	H		
Liliaceae	brown beige, 3.5 mm	H		
Malvaceae	orange, 2.5 mm	H	P	V
Malvaceae	light beige, 2.5 mm	H	P	V
Malvaceae	orange yellow, 2.5 mm	H		V
Malvaceae	creamy yellow, 2.0 mm			V
Malvaceae	dark orange, 2.0 mm			V
Malvaceae	light yellow, 2.5 mm			V
Mimosaceae	dark brown, 2.5 mm			V
Moraceae	yellow brown, 2.5 mm			V
Moraceae	brown with yellow tinge, 2.5 mm			V
Moraceae	orange yellow, 2.5 mm			V
Moraceae	light yellow brown, 3.0 mm			V
Moraceae	beige brown, 3.0 mm	H		
Moraceae	light yellow, brown, 2.0 mm			V
Myrtaceae	chalky white, 2.0 mm	H	P	V

TABLE 1. Pollen types collected by honey bees in Hakalau (H), Panaewa (P), Volcano (V), Hawaii including pellet description and floral source identification to family level. *(Continued)*

Floral Source (Family name)	Pollen Pellet Description (color, size — mm)	Locality		
Nyctaginaceae	yellow, 3.0 mm		P	V
Oenotheraceae	light brown, 2.5 mm		P	
Palmae	medium beige, 3.0 mm	H	P	V
Palmae	light brown, 2.5 mm			V
Palmae	chalky white, 1.5 mm		P	
Palmae	dark orange, 2.5 mm			V
Palmae	bright orange, 2.5 mm		P	
Palmae	yellow, 2.0 mm	H		V
Palmae	orange brown, 2.5 mm		P	
Pandanaceae	yellow beige, 3.0 mm	H	P	
Papilionaceae	yellow brown, 3.0 mm	H		V
Papilionaceae	light brown, 3.0 mm	H		
Papilionaceae	light brown yellow, 2.0 mm		P	V
Papilionaceae	gray orange, 2.5 mm	H		
Papilionaceae	yellow, 2.5 mm	H		
Papilionaceae	yellow, 2.0 mm	H	P	
Plantaginaceae	light yellow and gray, 2.5 mm	H		V
Rosaceae	yellow brown, 3.0 mm		P	
Rosaceae	dark brown, 4.0 mm	H		
Rubiaceae	light yellow beige, 2.5 mm			V
Rubiaceae	light yellow, 3.0 mm	H		V
Rubiaceae	yellow beige, 2.0 mm			
Rubiaceae	beige, 2.5 mm	H	P	V
Santalaceae	orange brown, 3.0 mm	H		
Santalaceae	yellow brown, 2.0 mm			V
Santalaceae	yellow, 3.0 mm		P	V
Santalaceae	green yellow, 3.0 mm			V
Solanaceae	light orange, 4.0 mm	H		
Solanaceae	light yellow, 3.0 mm	H		
Solanaceae	light brown, 3.0 mm	H		
Solanaceae	yellow orange, 3.0 mm	H		
Solanaceae	bright yellow orange, 2.5 mm	H	P	
Solanaceae	dark olive green, 2.0 mm	H	P	V
Solanaceae	bright yellow, 2.5 mm	H	P	
Solanaceae	brown orange, 2.0 mm			V
Solanaceae	brown yellow, 3.0 mm	H	P	V
Solanaceae	dark orange brown, 2.5 mm	H		
Solanaceae	white, 3.0 mm			V
Solanaceae	dark beige, 3.5 mm		P	
Sterculiaceae	light yellow, 2.0 mm			V
Ulmaceae	dark orange brown, 2.5 mm	H		V
Urticaceae	light yellow brown, 3.0 mm			V
Urticaceae	light brown beige, 3.0 mm	H	P	
Urticaceae	brown, 3.0 mm	H	P	V
Urticaceae	bright yellow, 3.0 mm		P	
Urticaceae	dull yellow, 2.0 mm		P	
Urticaceae	orange brown, 2.0 mm			V
Urticaceae	yellow brown, 2.0 mm			V
Violaceae	bright yellow, 3.0 mm		P	V

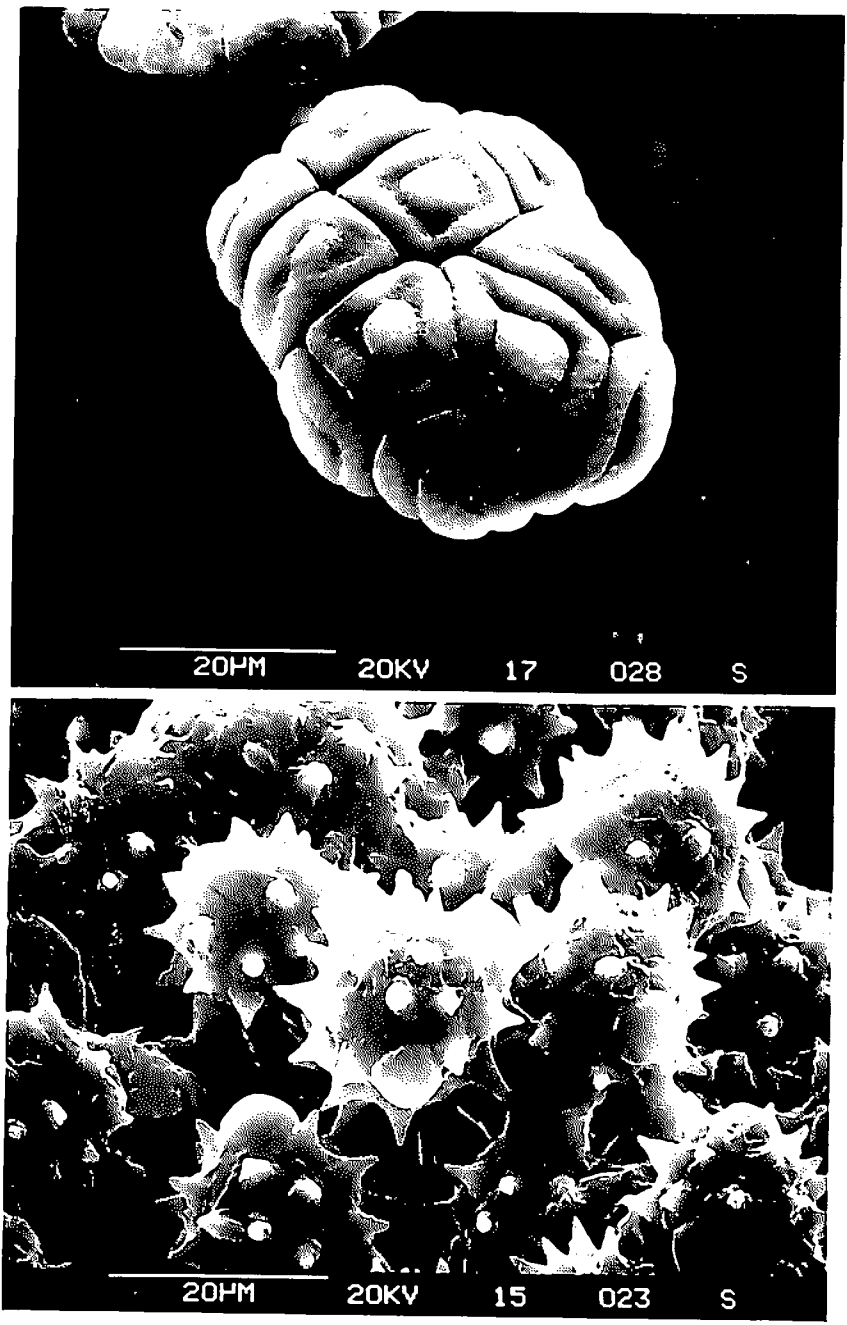

FIGURE 1. Scanning Electron Micrographs of typical pollen grains; above, Family Mimosaceae; below, Family Compositae.